FAA-00-7953-15

127008

Comments on DOT NPRM Licensing and Safety requirements for Launch
Docket Number FAA-2000-7953
(Lou Gomez, NMOSC, 505-521-3407)

Overall Comment:

We recognize the NPRM is written for launch of commercial ELV's, from a non-federal or federal launch site and that licensing requirements of 14 CFR part 415, subpart C apply to any launch from a non-federal launch site where a federal range performs the safety function. However, at some point in time we feel that an NPRM will have to be written to cover launch of RLV's from a non-federal launch site from other than sites located on the eastern or western coasts. These comments are being submitted with a view toward assisting the FAA in the drafting of an NPRM, which addresses launch of RLV's from a non-federal inland launch site.

General Comments:

1. For the most part, the draft requirements do not include the launch of Reusable Launch Vehicles (RLVs) or unproven vehicles even though it is written for non-federal launch sites. We are in the process of trying to develop a spaceport for use by reusable vehicles and need to understand the regulatory environment that we are going to have to comply with. NM and other inland states are expending funds and talents in the quest to host the next US spaceport. However, we need to know what the ground rules will be so that we head in the right direction.

2. The FAA provides no guidelines for launching Reusable Launch Vehicles (RLV's) from non-federal launch sites for licensing and flight safety. It appears that FAA plans to review applications for RLVs from a non-federal launch site on a case by case basis. This is good and bad. From a positive view point it avoids imposing expendable launch vehicle requirements on sites planned for RLV operations. However, it requires the RLV site operators, like New Mexico, to guess what the FAA will require in the license application. An operator could spend a lot of money and time preparing an application, only to find that the application is not acceptable. We understand the FAA's reluctance to venture into RLV's, however, we believe they should provide more in the way of guidelines for RLV-non-federal launch sites.

3. The NPRM appears to be procedure based rather than performance based. The requirements of AF document EWR 127-1 used at Cape Canaveral and Vandenberg are being imposed on all federal and non-federal launch sites. There probably should be some provision for other launch sites like the Army's White Sands Missile Range (WSMR) to use their own procedures which may not be like EWR-127, but are just as effective.

4. The proposed regulations relate only to launch operations. We suggest that the proposed regulations be expanded to include landing/recovery operations.

5. The National Academy of Science has really not taken all possibilities into consideration when coming up with some of their recommendations. It is good that the FAA has found them lacking. The whole idea of cut lines and gates needs to be carefully thought out. As a matter of general interest, WSMR has found some very safe ways to carry out staged missile flight overland without an overly restrictive methodology. Drop zones that are basically uninhabited are available to launch sites that are found in the western United States so that suborbital staged expendable launch vehicles can be safely flown out of inland launch sites using methodology that is different from WTR and ETR.

6. With regard to failure modes, risk, and safety analysis, we suggest looking at the problem from a systems approach. This makes using general rules, as has been done in the past, a poor way of doing things. The analysis should be done using a flight timeline and by taking site and vehicle characteristics into consideration. The FAA has acknowledged this new methodology by noting that

the safety analysis done on the Russian ELV launched from a platform far out in the Pacific violated some general rules and still appeared to be safe. Also it is very important to remember that the cost of arbitrarily applying general rules could be very significant.

7. The NPRM has opened up the issue of acceptable risk again with a modification of risk to a single individual at 1×10^{-6}. What is the basis of this change? How does the FAA plan to quantify acceptable risk and how do you propose to justify the values?

8. A great deal of space is given to debris falling on ships. Why is this any different from debris falling on buildings? These analyses should be done for worst case situations and include an assortment of ground (and ocean) based structures and scenarios. The analysis would show the effects of sheltering and allow us to modify the beta values of debris for cases where portions of the population are sheltered by a variety of structures.

9. There has been no discussion about reusable launch vehicles. Due to the way these RLVs are built, operate, and fly the whole safety philosophy for these vehicles will be very different from that of expendable launch vehicles. The following comments are offered with the view toward helping the FAA draft standards for RLVs.

   The philosophy of RLV launch, flight, and landing and ground and flight safety methods is expected to be somewhat different from the philosophy of ELV's and unguided rockets. The old flight safety method was a reactive system while the new RLV system is expected to be more proactive.

   Ground safety for the NM Spaceport should be mostly based on industrial standards since hazards at the Spaceport are expected to be similar to those presented by industry in the U.S. Fuels for all the RLVs that the NM team has examined have been for the most part liquid oxygen and liquid hydrogen. ELVs on the other hand tend to use very toxic and very explosive fuels. Non-flammable spills of large quantities of these LOX-LH liquids can be very dangerous but there would be ground safety precautions made for this hazard. Pad fires could be serious but not nearly so hazardous as pad explosions of other fuels. New Mexico has about 50 miles in radius around its launch complex that has almost no population in it and a total of less than 3 million people in a radius of 200 miles in all directions around the launch point. New Mexico rather than having very strict corridors would characterize the population centers over or near our likely commercial paths to orbit so that in the remote case of an emergency, the launch director would have a real time view of the changing hazard posed by a malfunctioning vehicle. In the case of a malfunction, an RLV vehicle is expected to act more like an aircraft needing to make an emergency landing. We will have determined numerous pre-selected landing sites to bring the disabled vehicle down at or if it occurs early enough (probably within the first minute of flight) return to the launch site. Most safety scenarios of rockets that malfunction are that of out of control bombs that must be blown up before they get beyond limit lines or into gates. One of the required analytical studies is that of a vehicle that does not make the turn to orbit but goes straight up. An RLV would probably be allowed to continue up until a selected level of fuel is burned off and then an attempt would be made to recover the vehicle at the launch site. Drastic turns during launch will be quickly analyzed using the real time data of hazards to population and if no control can be brought to bear on the vehicle attitude, the FTS would terminate fuel to the engines and the vehicle would crash land in an unpopulated area. This action would be delayed or speeded up depending on fuel load condition and the location of the IIP shown on the launch director's real time display. In other words NM would not expect to do a large amount of analysis for many of these activities. Instead we would do a large amount of data gathering and planning so that when an emergency occurred we would have large amounts of information displayed in real time to the launch director for him to make good safe decisions.

   Our analysis of VentureStar has shown that the first minute of flight is probably the most risky portion of vehicle flight. The IIP during this time is only a few miles from the launch site. In NM, the first 160 seconds of flight, which is, the next most risky portion of flight (in an estimated 340-second total burn) shows the IIP at about 200 miles from the launch point. There are less than 3 million people in all directions from the NM launch site. There are approximately only 500,000 people in all the wide slices of directions to the east from northeast to southeast out to 200 miles, which are considered to be launch paths. There are less than 300,000 people in wide slices of directions to the west out to 200 miles, which are considered to be landing paths. This low population density where emergencies are more likely to happen can for NM be shown to create a very low risk environment for RLV flight. Our analysis will be tailored to this unique set of circumstances without going into an extensive academic analysis of safety issues that do not apply to us.

We believe that the FAA should itself become proactive in the area of aircraft safety by developing an emergency plan to clear airspace in the event of a rare space flight anomaly. Any space vehicle in an emergency that is predicted to re-enter NAS intact or in pieces should be able to warn the FAA generally when, where, and how widely spread that activity might be so that NAS could be cleared of aircraft by fleeing the area or landing immediately. Much of the risk to aircraft in flight is that of very small debris effecting the "bring down" of the aircraft. By landing immediately and getting the passengers into a safe structure, the risk is greatly reduced. The same may be possible with ships at sea so that ships could attempt to leave the hazard area and at least make sure no one is on deck during the warning period. The sheltering aspect of greatly reducing expected casualty should be a major consideration in this work. Previous analyses indicate that 58 ft-lbs has only a 10% risk of death and a 90% risk of injury for people in the open. We would expect further analysis to show that sheltering people in an automobile or even a wood-frame with brick exterior home would allow multiples of 58 ft-lbs to be used as the standard. Steel reinforced concrete buildings would allow much higher values to be used as a safety standard.

10. There are a number of general rules still being applied by the FAA. Explosive FTS still seems to be a requirement. This will have to change for manned RLVs when they start flying. Also a required set of analyses listed in the NPRM may be a mistake. A fundamental set of required analyses might be appropriate but once specific failure modes, site, and vehicle characteristics are determined, then a detailed set of analyses can be decided upon. When to activate an FTS on an RLV will be as important as what the hardware makeup of the FTS is and how it is tested and certified.

11. Analysis using past wind data is interesting but not very practical on launch day other than determining if the launch should occur under those studied conditions. It might be better to find ways to determine what the winds are actually like along the flight path at that moment (and during climbout). This would give practical input to the launch director so that he would be assured that if there were a flight anomaly, risk would be within safe bounds.

12. The great amount of words that give all the general rules for a flight termination system ignores a systems approach to the problem. The FTS of future vehicles may be the flight control system (FCS) of the vehicle. Or there may be FTS elements buried in the FCS. It is probably smart to use redundancy, design analysis, flight-qualified components that are thoroughly tested to the environment that they will be flying in for both the FTS and FCS. From a systems point of view, how and when to engage the FTS is just as important as the hardware make-up of the FTS. Discussion of these broad requirements is probably all that is necessary at this point. Specific requirements will be based on a specific vehicle. Early instrumented test flights for new vehicles will determine the best location for the FTS and thus the most benign environment for the system. Instrumentation will determine the environmental characteristics and then the FAA would to decide whether to make the Qualification test TBD% above those levels. Most of this environmental data is already available for existing ELVs and should probably be cited.

13. With regard to the gate analysis. Should it be related to casualty risk? In the case of an RLV overflying land and population centers, some kind of instantaneous charting of these areas of risk with the IIP might be graphically presented to the launch operator. This would allow an operator in an emergency to make good real time safety decisions rather than having "gate" criteria that requires split second decisions. These split second decisions as the vehicle reaches a gate could be more dangerous than making no decision at all.

14. Extensive discussion of FTS batteries is handled in the Appendix. By limiting the FTS to a NiCad battery that is tested in a specific manner, the FAA may limit industry in coming up with better ways to meet the requirements using other types of batteries. Examples of systems and tests might be given to help newcomers but only after a solid list of requirements are presented. This again is a case where a systems approach to the problem would look at the problem from a variety of directions such that we would be assured that nothing is forgotten and that outdated technology and ideas would not be arbitrarily used.

15. As indicated in several locations, such as page 63924, there seems to be somewhat of a double standard. The FAA admits that non-federal launch sites would be held to higher standards than federal sites.

Specific Comments

1. Page 63924, Proposed Revisions to Part 415 and 415: Why not build instead on aspects of land overflight that have been demonstrated at inland military Ranges through several hundred successful flights of ballistic missiles over large expanses of low populated land. Such testing would allow RLV's to demonstrate one of their key advantages - an abort capability. Open ocean flight is unforgiving in providing recovery opportunities or even in positive diagnosis of fault through recovery of hardware disallowing a badly needed steep learning curve that encourages enterprise investment. Also the inland Ranges of western U.S. afford access to critical infrastructure, such as military down-range abort sites, down-range tracking and communications links, land space for incremental/flight expansion tests which are all a critically needed by startup companies.

2. Page 63925, Adherence to technical requirements and the Air Force legacy will limit human ingenuity so vital to allow U.S. Space Launch industry to compete in a world market. We question whether the current state of airplane would have evolved using the rigid standards in use today by the Air Force at Space Lift Ranges. Several hundred ballistic missile flights without injury or death also attest to that fact that a simpler therefore less costly performance based standard such as RCC 321-97 and 321-00 would be adequate but allow the freedom of creativity and design so important to innovation. Why start with EWR 127-1 when all the military Ranges including 30th and 45th Space Wing had already endorsed the RCC 321 standard as a yardstick from which to uniformly quantify risk.

3. Page 63925, Over 1100 sounding rocket launches have occurred at an Army Range in western U.S., more than in any other part of the free world. These included the first series of commercial launches. Wind weighting and all the factors described in DoT/FAA NPRM are used. It seems illogical that the DoT/FAA is teaming with the Air Force to build rules for suborbital launches.

4. Page 63928, We feel that the avoidance of inhabited land overflight will become a difficult issue for any Space Launch facility inland or over water. The criteria safety issue must be that of risk under nominal and failure conditions of flight do not exceed allowable risk limits. Dwell time of the hazard is clearly part of the equation. This aspect has been the driving factor in the safety planning for the hundreds of overland flights conducted safely over significant but limited population portions of western U.S. over the past 40 years. With Space Launch facilities being starting in other parts of the world too, the overflight (i.e., Instantaneous Impact Hazard not vehicle present position) is truly an international issue. Whatever is done through the NPRM ought to be consistent with current and anticipated future State and Commerce Department policy (e.g., NAFTA, treaties, territorial limits, airspace sovereignty, etc.). The possibility should not be ignored that, depending on what is ahead, the inland Spaceport may afford the advantage of being able to control debris for a longer period of time over friendly land territory.

5. Page 63929, Proposed policy is heavily weighted in consideration only of over water launches. Unless it is the intent of this document to preclude any possibility of inland launches, much of what is proposed here makes little sense for land locked Ranges. It is essential that inland Ranges be allowed early-on direct representation/participation in building such a far reaching set of rules

6. On page 63930 The FAA proposes to require that a launch operator initiate flight only if the probability of the launch vehicle or debris impacting any individual aircraft that is not operated in direct support of the launch does not exceed an individual probability of impact of 0.00000001 (P_i = 1x 10 $^{-8}$). We're concerned about the way aircraft risk is approached. First of all, We understand that there may be 300 people on an aircraft that could be killed by a single piece of debris, but shouldn't the approach consider that the real nature of aircraft risk might be much different than the risk to individuals on the ground. It seems that many pieces of debris that could be dangerous to unprotected individuals would not be all that dangerous to aircraft, but some debris that would be relatively harmless to individuals (i.e. "clouds" of small pieces) could damage engines and bring down the aircraft. Is it possible to use the criteria, which is now being used for commercial aircraft?

7. Page 63930, Why not also apply the exception granted for aircraft risk from large 3-sigma sounding rocket dispersion to overland risk? Bottom line ought to be what is the assessed Pc or Ec.

8. Page 63931, What about off shore drilling rigs? These should be treated as stationary population or small towns and afforded the same level of protection.

9. Page 63935, What about risk to operating aircraft? Depending on composition, as a result of aircraft velocity, Sandia National Labs has shown that debris as small as 1 gram steel or 3 grams aluminum can penetrate the skin of certain types of aircraft or pose engine ingestion problems when encountered in sufficient number.

10. Page 63937, Contribution of Risk due to an FTS failure. The FTS design spec calls for .9995 reliability (Pfail – .0005) at 95% confidence. The wide variety of failure scenarios possible given the failure of the FTS to function generates a hazard containment surface danger area the size of the vehicle maximum energy footprint including secondary affects of overpressure and toxins. Depending on how early in flight this occurs, because of the wide possibility of outcomes, the distribution of hazard within this area is totally indeterminent. Using a uniform distribution, if this surface hazard footprint is small relative to the containment domain of impact locations risk given the failure would soon approach the 30 x 10^{-6} level. Its only real value would be in the immediate launch area. These areas are usually evacuated. We are rapidly reaching a point of diminishing returns in attaining a comprehensive measure of risk with a significant increase in complexity of analysis starting because of the large number of best engineering judgment estimates required. One would also consider the inadvertent / erroneous / wrongful activation of the FTS as a debris producer and therefore also possible risk producer.

11. Page 63939, FTS reliability is allowed through qualification involving robust design, comprehensive qualification and acceptance testing of components and preflight confidence tests. We feel this same policy should also be applied to flight critical hardware and software if performed for an RLV, allowing use of a Pfail factor distributed over time in Ec mission risk computation.

12. Page 64050 indicates that a TNT equivalent for a liquid hydrogen and oxygen explosion is 14% of total fuel weight. Is this a value for a ground impact explosion?

Appendices

1. Appendix H to Part 417, Safety Critical computing systems and software.

Because the NM spaceport is adjacent to the White Sands Missile Range (WSMR) and because flights will be passing over White Sands Missile Range controlled airspace the WSMR flight safety system will be used.

It appears that the NPRM drives the design of operator's consoles. In the case of WSMR the consoles are designed and operating and the software baselines. The NPRM should includc provisions for allowing tried and proven safety computing systems and software such as the system used at WSMR, NM.

2. Appendix 1 to Part 417 Methodologies for toxic release hazard analysis

Thc NPRM shows the toxic level for hydrazine at 8 ppm. The toxic level for hydrazine has been 10 ppm for years.